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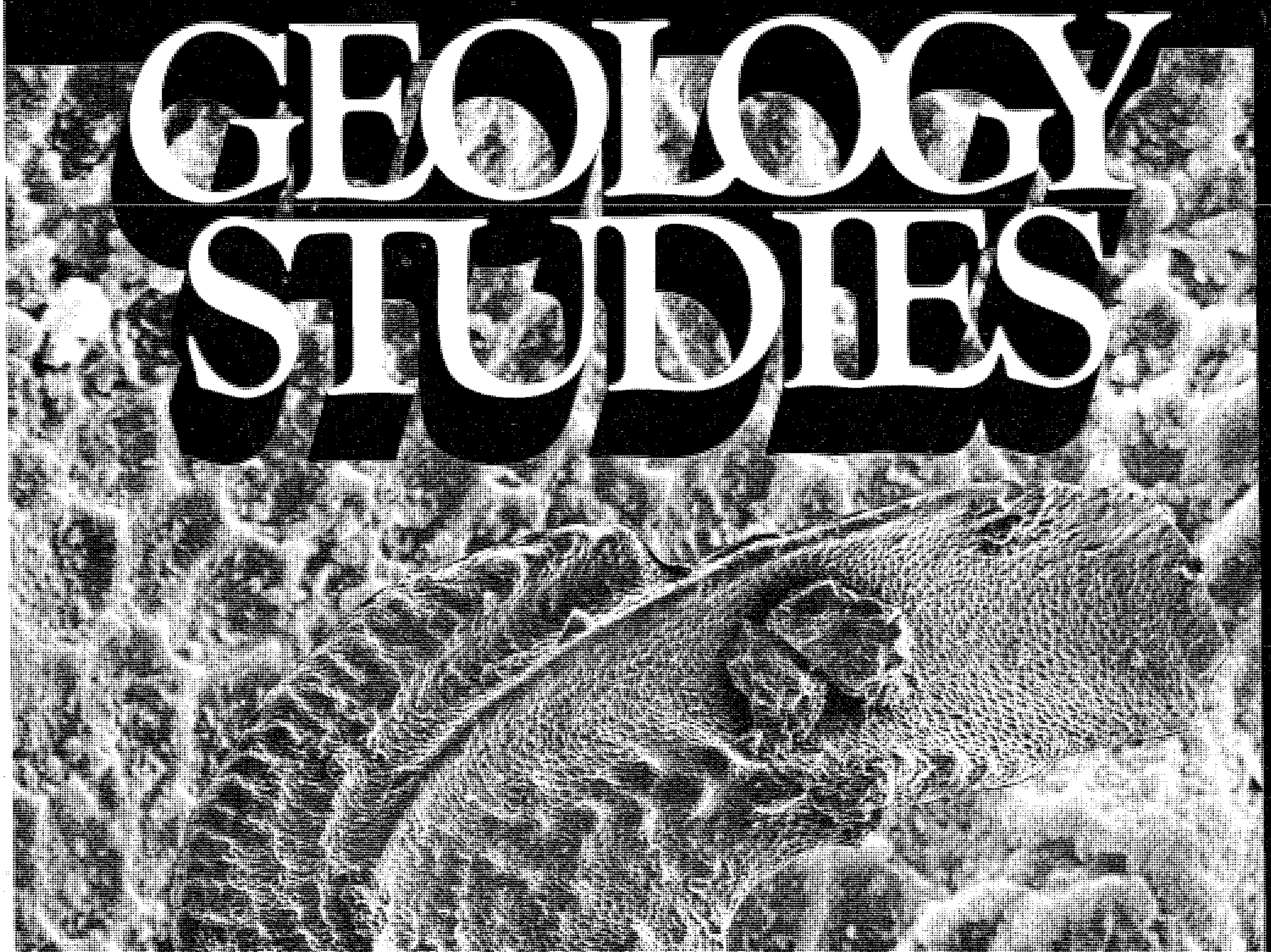

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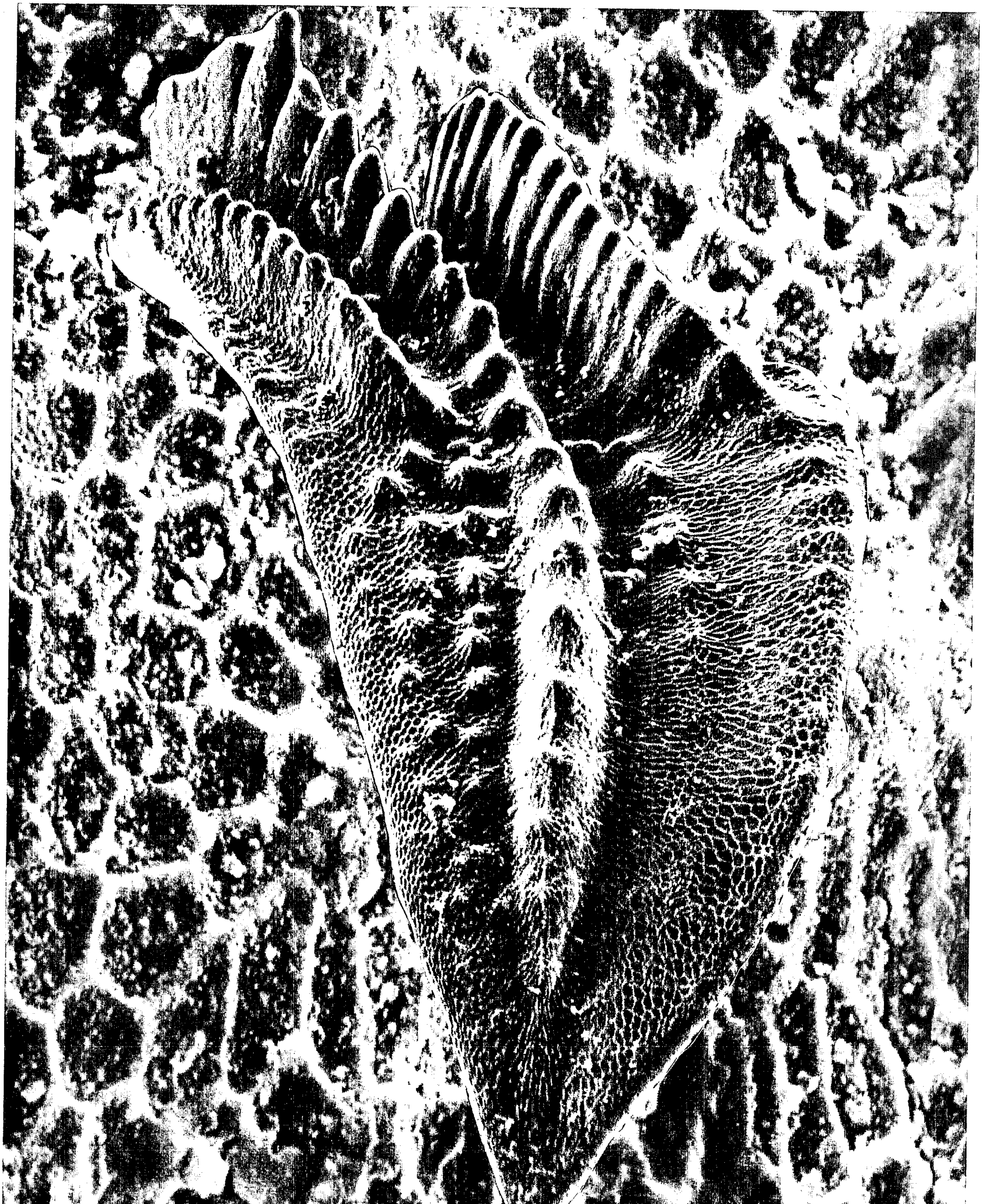

Brigham Young University Geology Studies

Volume 26, Part 3

Conodont Biostratigraphy of the Great Basin and Rocky Mountains

The proceedings of the Pander Society symposium, workshop, and post-meeting field trip held in conjunction with the Rocky Mountain section, Geological Society of America, at Brigham Young University, Provo, Utah, on April 28–May 2, 1978

Charles A. Sandberg and David L. Clark
Editors

Front cover: Late Devonian conodont Palmatolepis rugosa ampla.
Inside front cover: Early Mississippian conodont Siphonodella isosticha. *Both are SEM photomicrographs. See preface for details.*

THE GLORY OF GOD IS INTELLIGENCE

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PREFACE

The distribution of papers of this symposium volume among the various geologic systems is a good representation of the focus of regional conodont biostratigraphic work in the Great Basin and Rocky Mountains, with one notable exception. Work on the Cambrian System by J. F. Miller is not included because it either had been already published or was scheduled for publication elsewhere. Moreover, the guidebook for the Pander Society field trip on Cambrian and Ordovician rocks, held on April 26–27, 1978, immediately preceding the symposium at Provo, Utah, has already been published (Miller 1978). Judging by the numbers of papers published here and elsewhere, conodont work in the Great Basin and Rocky Mountain regions appears to be focused primarily on the Ordovician, Permian, and Triassic Systems, and secondarily on the Cambrian, Devonian, and Mississippian Systems. It is noteworthy that no papers in this volume are devoted to the Silurian and Pennsylvanian Systems. Although some work on these systems in the Great Basin has appeared in the past, the editors were unable to find workers actively enough engaged in studies of these systems on a regional basis to contribute to the present symposium. Hence the Silurian and Pennsylvanian Systems appear to offer fertile, uncrowded fields for future investigators.

In editing the papers of this symposium volume, an increasing awareness of conodont biofacies was noted among authors of all systems. Although there is still some indication that provinciality of conodont faunas existed in the western United States during limited intervals of geologic time, it is becoming evident that more and more seemingly provincial conodont faunas are being encountered as conodont studies extend westward off the former shelf into more offshore, deeper-water realms in central Nevada. Continued work on several systems in the Great Basin region may eventually discern as many lateral biofacies as the eight that have been recognized in the *Polygnathus styriacus* Zone of the Upper Devonian in the same region by Sandberg (1976) and Sandberg and Ziegler (1979). As demonstrated by Sandberg (1976), the combined Rocky Mountain and Great Basin regions offer an unparalleled opportunity for conodont workers to study faunas of the same age in a transect of environments, ranging from peritidal to far offshore pelagic—even including rises surrounding island arcs.

The front cover and inside front cover of this volume, which show the Late Devonian conodont *Palmatolepis rugosa ampla* and the Early Mississippian conodont *Siphonodella isosticha,* respectively, against a background of platform-conodont micro-ornamentation, were composited from SEM photomicrographs made at the Fachbereich Geowissenschaften, Philipps-Universität, Marburg, Federal Republic of Germany, under the direction of Prof. Dr. Willi Ziegler, to whom we are grateful for permission to use them.

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Permian Conodont Biostratigraphy in the Great Basin

David L. Clark,[1] Tim R. Carr,[1] Fred H. Behnken,[2] Bruce R. Wardlaw,[3] and James W. Collinson[4]

[1]*University of Wisconsin–Madison, Madison, Wisconsin 53706*
[2]*Augustana College, Rock Island, Illinois 61201*
[3]*U.S. Geological Survey, Denver, Colorado 80225*
[4]*The Ohio State University, Columbus, Ohio 43210*

Abstract.–Permian conodonts were reported first from Wyoming on the northeastern margin of the Great Basin in 1932. Twenty years later, the first Permian fauna was described from Idaho on the northern edge of the Great Basin. Since these early reports, Permian conodonts have been described in many parts of the world, but the biostratigraphy developed has been based largely on Great Basin work.

The early development of Permian conodont biostratigraphy in the Great Basin was handicapped by the lack of precise correlation with fusulinids and ammonoids that formed the basis for Permian biostratigraphy in the "type" areas. During the past 5 years extensive work in the biostratigraphically documented New Mexico–west Texas Permian section has provided a firmer basis for Great Basin biostratigraphic classification.

It is now possible to recognize 4 Sakmarian, 4 Artinskian, 4 Guadalupian, and 1 late Amarassian (or post-Amarassian) conodont assemblages. These assemblages include species of *Idiognathodus*, *Streptognathodus*, *Sweetognathus*, and *Neogondolella* in the Sakmarian; *Neostreptognathodus* in the Artinskian; and *Neospathodus* and *Neogondolella* in the Guadalupian. The sequence of 13 conodont assemblages represents all parts of the Great Basin Permian and supports the idea that all except the Dzhulfian Series are more or less complete in the Great Basin. These data represent a considerable improvement over the first Permian conodont biostratigraphy published in 1971 but leave considerable latitude for additional research.

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INTRODUCTION

Early History

The first report of Permian conodonts was from the Phosphoria Formation in western Wyoming by Branson (1932). Although this report was not of a Great Basin occurrence, it is of historical significance because it documented that a Permian stratigraphic unit that occurred in the Great Basin contained conodonts. Almost 10 years after this report Ellison (1941) recorded the occurrence of midcontinent Permian conodonts, and later Youngquist, Hawley, and Miller (1951) described Permian conodonts from the northern margin of the Great Basin.

The synthesis of Clark and Ethington (1962) described Permian conodonts from areas around the Great Basin (New Mexico, Arizona, Wyoming, Idaho), and Rhodes (1963) based description of several Lower Permian species on material from the Tensleep Formation in Wyoming. Work on the extensive Permian section of the Great Basin did not begin until the early 1960s, and the first Great Basin reports are those of Behnken (1969) and Clark and Behnken (1971). During the 1970s, reports of Clark (1972, 1974), Behnken (1975a, 1975b), and Collinson and Wardlaw (1977) have expanded our knowledge of Great Basin Permian faunas. Thus, study of Great Basin Permian conodonts was initiated less than 20 years ago, and the only published record is that of the present decade. Even this Spartan record is significant because it has formed the basis for a large proportion of the present worldwide Permian conodont biostratigraphy (e.g., Kozur 1975).

Classification Problems

Early biostratigraphic determinations with Great Basin Permian conodonts were only partially satisfactory. Classification of the age of the conodonts was difficult because of the lack of any standard of comparison. The associated Great Basin invertebrate fauna was useful only for large-scale correlation. In formulating such correlations, Clark and Behnken (1971, p. 418) summarized, "Many sections in the ... area are known to be Permian because of their stratigraphic position, or because they contain a few faunal elements of Permian type.... Details of positions within a series are lacking." The absence of a conodont standard based on worldwide recognized series or stage correlations created a very fundamental problem for Permian conodont biostratigraphers. This problem has been solved during the past few years, largely because of extensive work in west Texas–the type area of the Lower and lower Upper Permian–by Behnken and his students and in the classic uppermost Permian by Sweet.

We are now able to interpret firm Great Basin stage classifications on the basis of the occurrence of the same species of conodonts in Nevada and Utah that occur throughout the west Texas Sakmarian, Artinskian, and Guadalupian series (fig. 1). This correlation and the resulting classification are the subject of this report. Our study confirms, among other things, that the Great Basin Permian represents a more or less complete sequence with the exception of the Dzhulfian series.

Current Research

The Permian series and stage names used for the Great Basin (fig. 1) are those proposed by Furnish (1973). Previous reports of "Wolfcampian" can be shown to correlate with stages of the Sakmarian Series as defined. Similarly, previous references to "Leonardian" have been accommodated in the more inclusive Artinskian Series, of which the Leonardian is the second stage. Usage of Guadalupian Series is similar to that published previously but with the addition of the Amarassian as the uppermost stage. Post-Amarassian conodonts may be present in the Great Basin Permian, but problems of classification with the Araksian Stage (or even the Dzhulfian Series) are discussed later. Conodonts from Sakmarian strata in the Great Basin have been studied by Clark (1972, 1974) in eastern Nevada and western Utah and Larson (in press) in central Utah. Current work includes study of a section of Sakmarian-Artinskian transition beds in central Nevada.

Artinskian and Guadalupian faunas are the subject of extensive work by Behnken (1975a, 1975b), Collinson and Wardlaw (1977), and Wardlaw and Collinson (1978) from sections in several parts of Utah, Nevada, and Idaho.

The youngest Great Basin Permian (post-Amarassian) is that reported by Clark and others (1977) from the Terrace Mountains in northwestern Utah. Carr (1977) and Carr and Clark (1979) have been responsible chiefly for the west Texas–Great Basin correlations.

Outside of the Great Basin, Kozur (1975, 1977) has published extensively on sections in several parts of Eurasia. He has proposed a conodont biostratigraphic scheme that is difficult to evaluate because of meager data on locality and accompanying biostratigraphic classification.

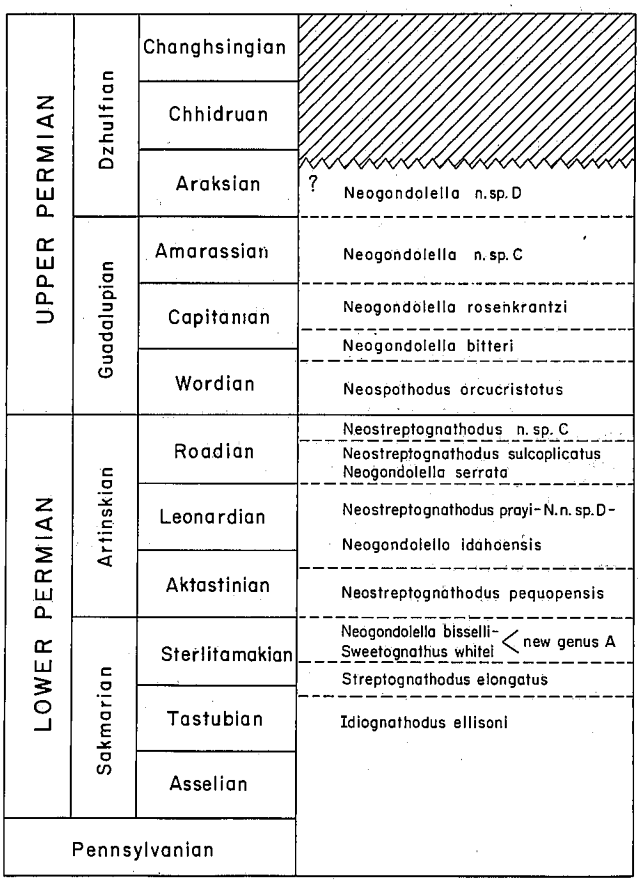

FIGURE 1.–Classification of the Permian and comparison with occurrences of conodont assemblages in the Great Basin

Also, of importance to our Great Basin work is the report of Rabe (1977) of Sakmarian species in South America. This report confirms the presence of North American Sakmarian species in the same sequence but outside of midwestern and western North America.

Present Study

A sequence of 13 conodont assemblages is now recognized for the Great Basin Permian (figs. 1, 2). Some of the assemblages have not been recognized in more than a single area, and the different assemblages may prove to have different values outside the Great Basin.

LOWER PERMIAN ASSEMBLAGES

Sakmarian

The lowermost of the four Permian series is characterized by at least 4 assemblages. The sequence is based on occurrences described originally in Nevada and Utah, but refined and classified on the basis of occurrences in west Texas. Apparently, the same assemblages occur in South America, but Eurasian reports (e.g., Kozur 1975) are difficult to evaluate.

Idiognathodus ellisoni *Assemblage*

The name-giving species characterizes an assemblage of predominantly Upper Pennsylvanian and Lower Permian species that range from Virgilian into basal Asselian and Tastubian rocks. In Nevada this assemblage occurs in the Ely Formation and overlying Riepe Springs Formation. In Utah the Virgilian and overlying Permian part of the Oquirrh Formation bear elements of this assemblage. It is also known in the Lenox Hills of west Texas. Species characteristic of this assemblage include *Gnathodus bassleri, G. roundyi, Adetognathus latus, A. gigantus, Streptognathodus elongatus, Anchignathodus minutus,* and *Gondolella bella.*

Perlmutter (1975) considered *I. ellisoni* to be a junior synonym of *I. wabaunensis* in the Kansas section. Comparison of type material (pl. 1, figs. 22, 23) indicates significant differences between the two species, however, and *I. ellisoni* is retained as the name of the principal component of the uppermost Pennsylvanian-lowermost Permian assemblage. It is apparent that conodonts on both sides of the Pennsylvanian-Permian boundary are the same species (fig. 2).

Streptognathodus elongatus *Assemblage*

The name-giving species is an important part of the *Idiognathodus ellisoni* assemblage in Texas (Lenox Hills Formation), Utah (Oquirrh Formation) and Nevada (Riepe Springs Formation), but it continues above the last occurrence of *I. ellisoni* into the *Neogondolella bisselli-Sweetognathus whitei* interval of the Oquirrh Formation (fig. 2). *Neogondolella bisselli* and *S. whitei* occur in the lower Hess Formation in Texas, as well. Associated fusulinids in Texas and Nevada establish a late Sterlitamakian age for this assemblage, thus fixing an age for the upper range of *Streptognathodus elongatus* (e.g., Ross 1959). *Streptognathodus elongatus* has been found to overlap the *N. bisselli–S. whitei* assemblage only in the Oquirrh Formation of Utah. In Nevada and Texas, the range of *S. elongatus* coincides with the range of *I. ellisoni.* If the Oquirrh specimens are not reworked (Larson 1977), this species defines an interval (upper Tastubian?–lower Sterlitamakian) above the upper range of *I. ellisoni* and below the first occurrence of *N. bisselli–S. whitei* (fig. 2).

Neogondolella bisselli–Sweetognathus whitei *Assemblage*

This assemblage characterizes an interval of the upper Sterlitamakian in Texas, Utah, Idaho, and Nevada. The name-giving species occur with *Ellisonia* spp., *Xaniognathus* sp., and *Anchignathodus* sp.—i.e., the post-Early Permian crisis fauna (Clark 1972, 1974).

New genus A Assemblage

The upper part of the *N. bisselli–S. whitei* assemblage is well defined by the occurrence of new genus A (fig. 2), a form described as *Gnathodus bucaramangus* by Rabe (1977). This new genus has been found in Colombia, Kansas, Texas, Nevada, and Utah and is subject of a separate paper (Carr and Clark 1979). In all these areas, it apparently characterizes a very restricted interval in the upper part of the *N. bisselli–S. whitei* assemblage. These species range lower and higher than the new genus, which marks a very precise Sterlitamakian interval.

Artinskian

The upper series of the Lower Permian is characterized by species of *Neostreptognathodus,* known in Texas, Nevada, Wyoming, and Idaho. Species of *Neostreptognathodus* occur with species of *Neogondolella* in most parts of the Artinskian, one commonly to the exclusion of the other. This tendency for mutual exclusion was noted early in the study of Permian conodonts (Clark and Ethington 1962) and may be explained by paleoecologic factors.

Neostreptognathodus pequopensis *Assemblage*

At the base of the upper Hess and Skinner Range Formations of west Texas and approximately 30 m (100 ft.) above the base of the Pequop Formation in the Pequop Mountains, Nevada, is the first occurrence of *Neostreptognathodus.* This occurrence coincides with the lower Aktastinian boundary, an age supported by correlation with fusulinids and goniatites (Lee 1975). The upper range of the *N. bisselli–S. whitei* assemblage overlaps that of the lowest occurrence of *N. pequopensis* (fig. 2).

The age of the upper occurrence of the name-giving species is uncertain. Its presence at the base of the Skinner Ranch Formation of west Texas, and no higher, leads to the assumption that it was extinct sometime before deposition of the Leonardian sediments.

Neostreptognathodus prayi–N. *n. sp. D*– Neogondolella idahoensis *Assemblage*

Neostreptognathodus prayi and *Neogondolella idahoensis* occur in the Skinner Ranch (upper Aktastinian) of west Texas along with *Neostreptognathodus* n. sp. D. This same assemblage has been found in several Great Basin formations (Loray, Arcturus, Kaibab). *Neostreptognathodus* n. sp. D includes some specimens of what earlier was referred to Leonardian *N. sulcoplicatus,* a species that now is restricted to younger Artinskian (Roadian) units (Baird 1975). Species of *Ellisonia* and *Anchignathodus*

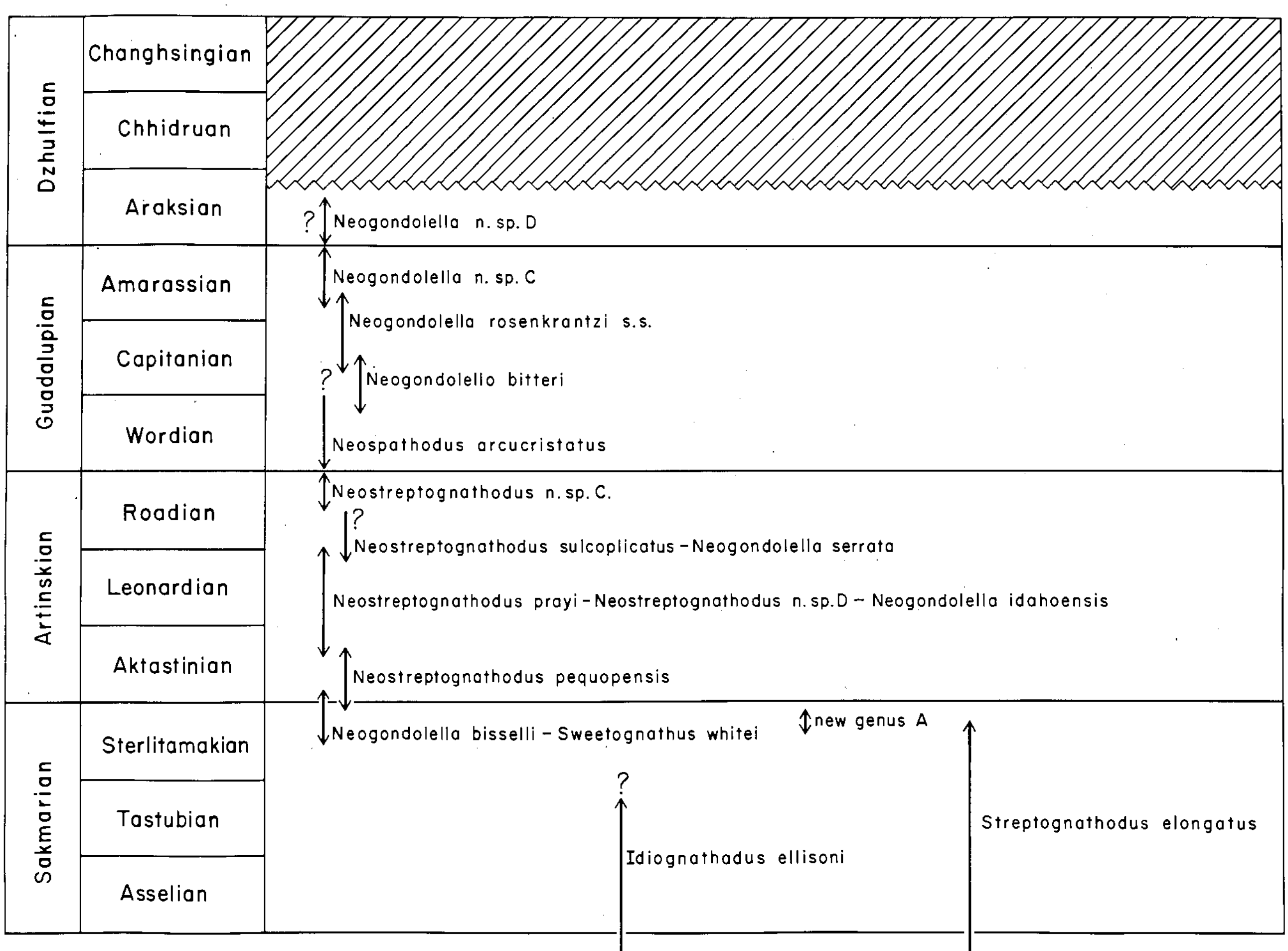

FIGURE 2.—Approximate ranges of conodonts in the Permian of the Great Basin.

(=*Hindeodus*) occur with other representatives of this assemblage. Several subdivisions of this unit appear possible.

Neostreptognathodus sulcoplicatus–Neogondolella serrata *Assemblage*

The basal Roadian assemblage is well developed in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation, the upper part of the Kaibab Limestone, and lower part of the Plympton Formation in the Great Basin. It also is present in the Bone Spring Formation and a part of the Cutoff Formation of west Texas. Species of *Anchignathodus* (=*Hindeodus*) and *Ellisonia* are also present. The *Neogondolella* species most commonly occur in deeper, more offshore facies than *Neostreptognathodus sulcoplicatus*. In the southern Wasatch Mountains they occur in the Park City Formation.

Neogondolella serrata occurs throughout the Roadian and into the basal Wordian. It is the ancestor of a whole complex of neogondolellids that are dominant in the North American Guadalupian sequence (Clark and Behnken 1979).

Neostreptognathodus *n. sp. C Assemblage*

This species occurs in the upper beds of the Kaibab Limestone in southern Utah and in the lower Plympton Formation in east central Nevada and west central Utah. It is thought to be upper Roadian on the basis of stratigraphic position below Wordian brachiopods and above definite Roadian conodonts and ammonoids (Baird 1975). In addition, *Penicularis bassi*, a Roadian brachiopod, has been found in the Plympton with this conodont species. *Neostreptognathodus clinei* occurs in this interval, as well as species of *Xaniognathus* and *Anchignathodus.*

UPPER PERMIAN ASSEMBLAGES

Guadalupian

The Guadalupian Series is characterized by a conodont fauna distinctly different from that of the Lower Permian. The important *Neostreptognathodus* species become extinct by the end of the Roadian, and the Guadalupian is dominated by species of the *Neogondolella serrata* complex (Clark and Behnken 1979). This species appears in the upper Artinskian, and its descendants occur throughout the Guadalupian.

The most continuous conodont record of the Guadalupian is that of the type area. There, carbonate tongues, extending into the Delaware Basin and associated with the Capitan reef mass, contain well-preserved *Neogondolella* and a few associated genera. This has been reported by Behnken (1975) and Babcock (1976). Details of *Neogondolella* evolution has been described, as well (Clark and Behnken 1979).

Great Basin Guadalupian conodonts are best developed in the Gerster Limestone. The variety of conodonts is neither as diverse nor as abundant as that of the Texas section.

Neospathodus arcucristatus *Assemblage*

The upper Plympton Formation and lower Gerster Limestone in Nevada contain a small fauna, the most distinctive species of which is *Neospathodus arcucristatus. Ellisonia* and *Anchignathodus* species are also present. Wardlaw and Collinson (1978) described a *Thamnosia depressa* brachiopod fauna from this same interval. The fauna is characteristic of at least a part of the Wordian Stage. It has not been recognized elsewhere but is thought to be equivalent to the *Neogondolella* n. sp. B fauna of the type Wordian (Clark 1979). The upper range of the name-giving species is not known (fig. 2), but it ranges as high as the Retort Phosphatic Shale Member of the Phosphoria Formation in Wyoming.

Neogondolella bitteri *Assemblage*

Overlying *Neospathodus arcucristatus* but overlapping its range in the Gerster Limestone is an assemblage, the most distinctive member of which is *N. bitteri.* In earlier studies (Clark and Behnken 1971), the material now referred to *N. bitteri* (Kozur 1975) was identified as *N. rosenkrantzi. Neogondolella bitteri* occurs with Wordian brachiopods in the Great Basin (Wardlaw and Collinson 1978).

Neogondolella rosenkrantzi *Assemblage*

This distinctive species characterizes an interval of the middle and upper Capitanian and, to a lesser degree, the Amarassian in Texas. The species was described first in Greenland (Bender and Stoppel 1965). Later, additional Greenland material was more thoroughly studied by Sweet (1976), who suggested that reports of this species outside Greenland were in error. There is evidence, however, that the species occurs in west Texas and the Great Basin (Clark 1979). In west Texas it occurs with *Neogondolella postserrata, N.* n. sp. B, and *N.* n. sp. C and was part of a complex of neogondolellids that evolved from the lower Guadalupian *N. serrata* (Clark and Behnken 1979). Earlier reports of *N. rosenkrantzi* in the Great Basin (Clark and Behnken 1971, Behnken 1975) have been confirmed by comparison with type material. In the Great Basin, *Neospathodus divergens* occurs in this same interval and earlier was considered the name species for this interval (Clark and Behnken 1971).

Neogondolella *N. sp. C. Assemblage*

Neogondolella n. sp. C is a distinctive member of the *N. serrata* complex, and it occurs in the Lamar Limestone of west Texas and the upper part of the Gerster Limestone in northwestern Utah (Clark and others 1977). This confirms an Amarassian age (uppermost Guadalupian) for part of the upper Gerster. The species occurs with *N. rosenkrantzi* in the lower part of its range and with *Ellisonia* spp., *Anchignathodus,* and *Xaniognathus. Neogondolella* n. sp. C most probably was the direct ancestor of *N.* n. sp. D, which marks the base of the overlying assemblage.

Neogondolella *n. sp. D Assemblage*

The youngest Great Basin conodont assemblage is that found in the upper few feet of the Gerster Limestone in section 2 of the Terrace Mountains, Utah (Clark and others 1977). *Neogondolella* n. sp. D is the final member of the North American neogondolellid stock. It demonstrates the culmination of a stage of morphologic evolution initiated by early members of the *Neogondolella serrata* complex (Clark 1979) and occurs in rocks that may be younger than the type uppermost Guadalupian. Because this form has not been found in Araksian (Dzhulfian) strata, it is not possible to classify the uppermost Gerster beds as Dzhulfian, however. The upper beds of the Gerster in the Terrace Mountains may be the youngest marine Permian in North America.

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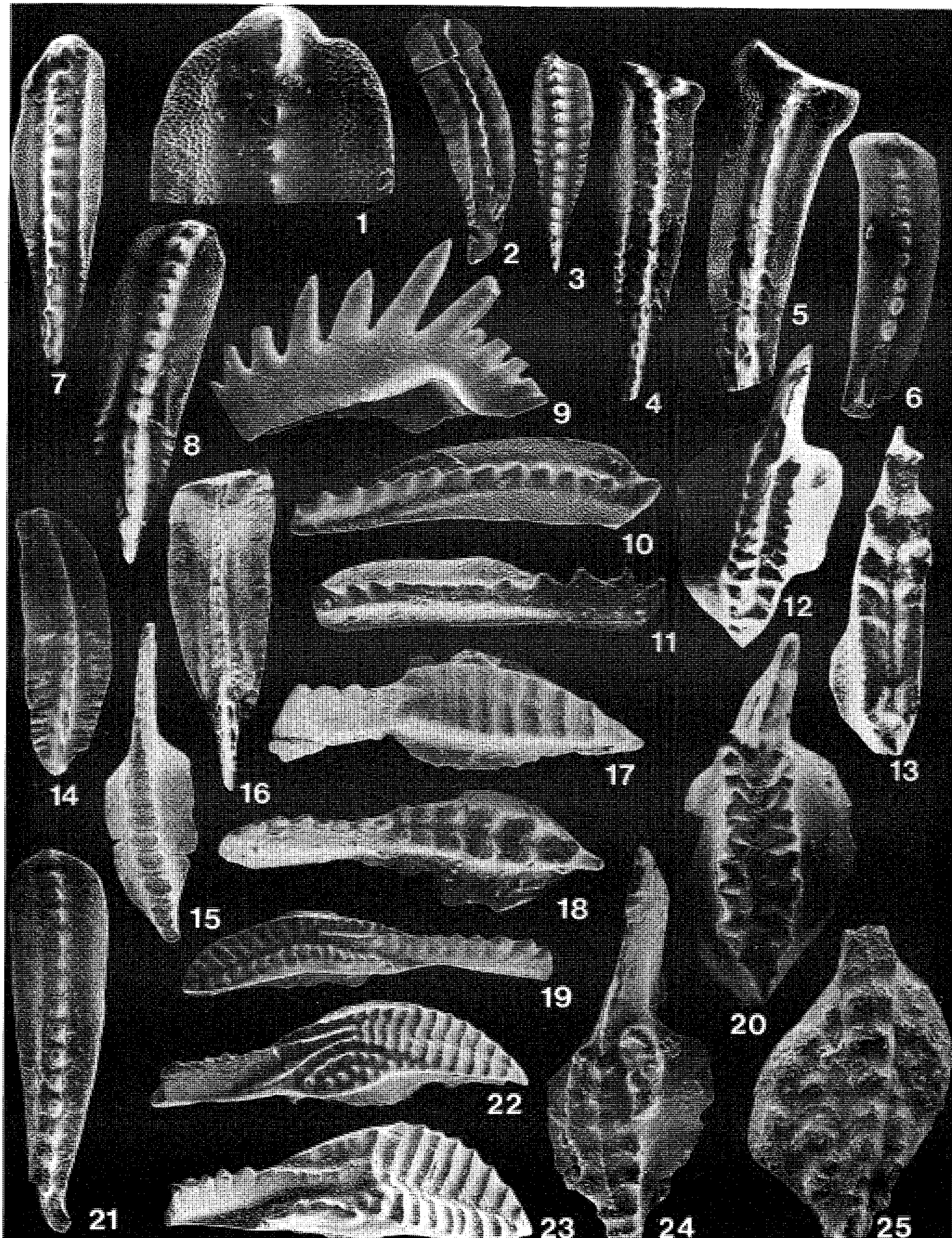
Addendum: While this paper was in press, specimens referred to *Neogondolella* sp. B, C, and D, have been described as *N. denticulata, N. babcocki,* and *N. wilcoxi,* respectively (Fide, Clark and Behnken 1979).

EXPLANATION OF PLATE 1

All specimens photographed at the University of Wisconsin, on the Department of Geology and Geophysics Jelco-SEM, except figures 6, 12, and 13. Figures 1, 2.–*Neogondolella* n. sp. D: 1, posterior end illustrating symmetrical characteristic, Gerster Limestone, Terrace Mountains, Utah, X100, UW 1679/32; 2, upper surface, notice anterior serrations and posterior symmetry, Gerster Limestone, Terrace Mountains, Utah, X40, UW 1679/28. Figures 3, 7–8.–*Neogondolella* n. sp. C, Lamar Member, Bell Canyon Formation, Texas: 3, holotype, X40, UW 1679/25; 7, X60, UW 1679/33; 8, X40, UW 1679/22. Figures 4–6, 16.–*Neogondolella rosenkrantzi* (Bender and Stoppel): 4, Rader Member, Bell Canyon Formation, Texas, X40, UW 1679/18; 5, topotype specimen from East Greenland, X50 (courtesy Geologisk Museum, Copenhagen); 6, Upper Permian of Wyoming, X82, USGS D125-PC, 6, B. R. Wardlaw photo; 16, upper part of Gerster Limestone, specimen with affinities to *N. rosenkrantzi,* may be gerontic *N. bitteri,* X45, UW 1428. Figure 9.–*Neospathodus arcucristatus* Clark and Behnken, lateral view of holotype, Plympton Formation, Nevada, X85, UW 1433. Figure 10.–*Neogondolella idahoensis* (Youngquist, Hawley, and Miller), Skinner Ranch Formation, Texas, X65, UW 1674–12. Figure 11.–*Neogondolella bitteri* (Kozut), Gerster Limestone, Nevada, holotype, X55, UW 1423. Figure 12.–*Neostreptognathodus* n. sp. C, Kaibab Limestone, Nevada, X120, OSU 31298, J. Collinson photo. Figure 13.–*Neostreptognathodus* n. sp. D, Kaibab Limestone, Nevada, X125, OSU 31300, Baird (1975) photo. Figure 14.–*Neogondolella serrata* (Clark and Ethington), Brushy Canyon Formation, Texas, X40, UW 1679/34. Figure 15.–*Sweetognathus whitei* (Rhodes), Oquirrh Formation, Utah, X50, UW 1643/12. Figure 17.–*Neostreptognathus prayi* Behnken, Skinner Ranch Formation, Texas, X75, UW 1674/16. Figure 18.–*Neostreptognathodus pequopensis* Behnken, Skinner Ranch Formation, Texas, X85, UW 1674/10. Figure 19.–*Streptognathodus* '*elongatus* Gunnell, Oquirrh Formation, Utah, X50, UW 1643/17. Figure 20.–*Neostreptognathodus sulcoplicatus* (Youngquist, Hawley, and Miller), Park City Group, Utah, X45, UW 1457. Figure 21.–*Neogondolella bisselli* (Clark and Behnken), Skinner Ranch Formation, Texas, X50, UW 1674/24. Figure 22.–*Idiognathodus ellisoni* Clark and Behnken, Riepe Springs Formation, Nevada, X50, UW 1679/35. Figure 23.–*Idiognathodus waubaunsensis* (Gunnell), Americus Limestone, Kansas, holotype, X60, Gunnell collection 519-3, courtesy of R. L. Ethington, University of Missouri. Figure 24, 25.–N. gen., Arcturus Formation, Utah, both X95, UW 1679/36.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